Discrepant event demonstrations
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Discrepant Event Demonstrations

Motivating students to learn science concepts

SCIENTIFIC DISCREPANT EVENTS CAN BE used to effectively teach science concepts and principles as a component of "the learning cycle" (TLC) instructional strategy. A scientific discrepant event is a phenomenon that occurs in a way that seems to run contrary to initial reasoning. This makes it a powerful device to stimulate interest and motivate the use of thinking skills in learning science concepts and principles at a deeper level (Wright and Govindarajan, 1992).

Scientific phenomena can vary in the extent to which they provoke awe and puzzlement. What is new, counter-intuitive, or discrepant with one person's schema may be somewhat familiar to that of another (Hyde and Bizar, 1989). The secret is to find examples of discrepant events that intrigue all students.

CONSTRUCTIVE INTERNALIZATION AND KNOWLEDGE

Although Lawson, Abraham, and Renner (1989) use conceptual change as the theoretical basis for TLC, it may also be approached from the constructivist point of view. We emphasize a constructive approach to learning science concepts and principles using discrepant events. TLC builds on a constructive framework of modifying parts of prior knowledge that have been falsified by unique experiential learning, or by learning new knowledge.

Cognitively, such experiential learning would have priority in long-term memory storage for the simple reason that the information has been processed as a result of a "deep approach to learning."

Iran-Nejad (1990), reviewing research on students' approaches to learning, concluded: "The majority—more than two-thirds—view learning as knowing more, memorizing for later reproduction, or acquiring and using facts. These students tend to take a surface approach to...learning. In sharp contrast are those—less than one-third—who believe that learning involves insights into the subject matter, new ways of thinking about reality, and personal growth. These students take a deep approach to learning."

Constructive internalization of knowledge is facilitated by the design of science instruction involving three steps: 1) pattern identification in the environment, 2) discussion of the occurrence and introduction of a reference term to identify the pattern, and 3) identification by awareness of the conceptual phenomena in new and novel situations.

TLC models the following three phases: The explo-

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ration phase emphasizes the investigation of the nature of patterns and the discovery of their regularity. The concept introduction phase paves the path to discuss data, clarify a pattern, and give it an identifiable name (term). The application phase serves to reinforce the learning activity by applying the concept in new situations.

The logic is that such an experience should ensure that students acquire meaningful knowledge and useful conceptual understanding; develop cognitive skills in directing thought patterns toward independent, creative, and critical ventures; and secure confidence in their potential toward applying their acquired knowledge in solving problems and making well-balanced judgmental decisions in an everchanging environment (Wright and Govindarajan, 1992).

EXAMPLES

Thompson (1989) correctly observes that too often science teachers consider discrepant events to be merely fun activities and do not use them with the possibility of illustrating science concepts and principles. When students express their alternate conceptions following observation of the discrepant event, the teacher is provided data to diagnose students' learning for misconceptions or preconceived notions that often do not have logically or scientifically sound reasoning.

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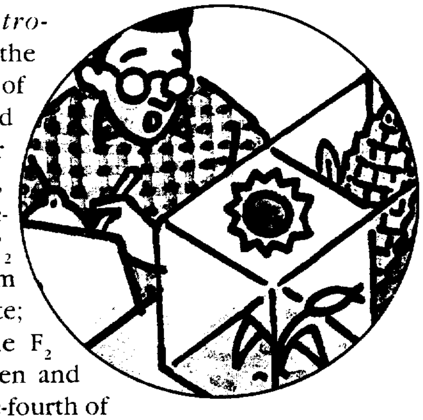
To illustrate the TLC/ Discrepant Event Model of Instruction, we provide four examples. For more examples, see Kavogli (1992), Thompson (1989), Wright (1981), Wright and Govindarajan (1992), and Govindarajan and Wright (1994).

BIOLOGY

A Real "Corn"-undrum—Can plants grow faster in darkness?

Exploration—Give small groups of students three different sets of corn seeds to plant. (One set should exhibit the phenotype for chlorophyll (carries the trait for albino), the second set should lack chlorophyll (albino), and the third should carry the trait for shortness.) Have the students record observations of the physical characteristics of the corn seeds before planting. Ask them to design an experiment to determine whether or not all the plants will grow the same and look alike in terms of color and height under conditions of light and darkness.

Once the seeds germinate, most students will be surprised to discover that corn seeds do grow faster in darkness, and that the germinated plants differ from one another in color and height.



Concept Introduction—Among the three different sets of corn seeds planted (growing under conditions of light), approximately one-fourth of the F_2 plants derived from set one will be white; in set two, all the F_2 plants will be green and approximately one-fourth of the corn plants will be short; and, in set three, approximately 9/16 of the plants are green and tall, 3/16 are white and tall, 3/16 are green and short, and 1/16 are white and short.

To conduct the experiment, the students were given F_1 monohybrid seeds that carry the recessive trait for albinism, a monohybrid F_1 generation set of seeds that carries the recessive traits for short plants, and a dihybird F_1 generation set of seeds that carries both the recessive traits for albinism and for short plants.

The students can now be introduced to the terminology associated with the structure and functions of the seed. This can be done by showing films, requiring library research, or assigning specific textbook or article readings. The students should learn that corn is a monocotyledon with one embryonic storage leaf and endosperm, both of which contain stored foods (macromolecules of starch, proteins, and fats). They should also learn that the plant growth hormone, indoleacetic acid (an auxin), produced at the tip of the corn shoots (apical meristem), stimulates rapid growth of new cells at the apices particularly in the absence of light. Such a phenomenon is called etiolation, the production of tall but spindly shoots. In the presence of light, however, the influence of the auxin is inhibited, which might result in the inactivation of the hormone, driving it to the lateral surface of the stem where it cannot function at its optimum.

Application—The application of new knowledge is particularly important. For instance, students could design an experiment to determine how other plants are influenced by the presence and absence of light. Other applications might include studying plants that grow on the ocean bed. For example, near the southern tip of South America, seaweeds that are nearly 182-meters tall continue to grow in the very poor light conditions of the Atlantic Ocean floor. Have students come up with working hypotheses to explain the phenomenon, basing their

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interpretations on the concepts and principles they have acquired.

EARTH SCIENCE

Fast Freeze—Hot water can freeze faster than cold water.

Exploration—Begin by stating that people in cold countries wash their cars with cold water because they believe it delays freezing. Most students doubt this belief. Have them conduct the following activity to find out for themselves that cold water does delay freezing.

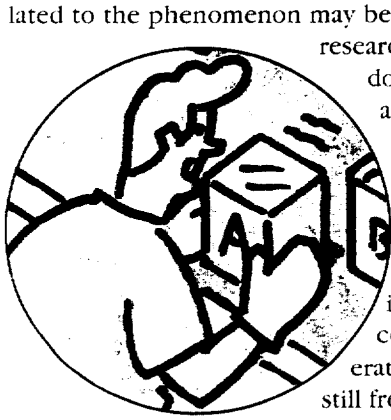
Label two stainless steel containers A and B, and fill each with 400 mL of water. Heat the water in vessel A to 60°C. Remove vessel A from the hot plate. Place both vessels in the freezer unit at the same time. Ask the students to hypothesize in which vessel the water will turn to ice first. Most will answer B, because colder water, already at a low temperature, will not take as long to freeze.

We cannot afford to leave scientific discrepant events unexplained.

Over a period of four to five hours, monitor the containers at equal intervals of 10 minutes for temperature changes. It will be observed that the contents of vessel A will begin to turn to ice first. Invite students to share their theories of how this occurred.

Concept Introduction—To begin with, the liquid in container A circulates more rapidly—when the vessel is heated, the molecular circulation in water causes more rapid transfer of heat energy to the wall of the vessel. The mobility of water molecules increases with every degree increase in heat. However, there is a limit to this. Second, more dissolved gas will be released from the warmer vessel. This enhances cooling. Third, the water evaporates quicker from the water surface of the warm vessel to the atmosphere. Thus, because more of the mass from the warm water is lost, there is less mass to cool. Therefore, warm water reaches the freezing point sooner than cold water does.

Application—An intriguing set of questions related to the phenomenon may be given to students for research or projects: How does an ice cube cool off a drink? Does the cube give off coldness or absorb heat? When both a hot water container and a cold water container are completely insulated from the cooling coils of a refrigerator, does the hot water still freeze faster?

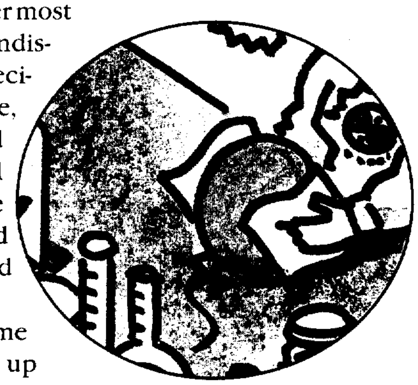


PHYSICS

Static City—Static electricity in the environment.

Exploration—Instruct a small group of students to fully inflate a balloon and tie it off with a 40-cm string. Next, rub the balloon briskly with a 15-cm square of wool fabric. Place the balloon against a wall and release it. The balloon will stick to the wall. Next, ask each group to inflate a second balloon, tie it off with string, and rub it briskly on the wool. This time, hold both balloons by their strings and bring them close together. They will move away from each other. Invite the students to explain their observations.

Concept Introduction—Atoms, and all matter, are made up of the fundamental particles: electrons, protons, and neutrons. Electrons are negatively charged, protons are positively charged, and neutrons have no charge. The charge on a proton is equal in magnitude to the charge on an electron. The nucleus of an atom, in general, is composed of protons and neutrons. The nucleus is surrounded by clouds of electrons. Whenever most objects are left undisturbed for an unspecified length of time, their protons and electrons are equal in number and the objects are regarded as having balanced electrical charges.



However, some objects will pick up excess electrons from material rubbed on them; still others transfer excess electrons to material rubbed against them. In the above discrepant event, when the balloon is rubbed on the wool, the balloon picks up excess electrons from the wool. Now the balloon is regarded as being negatively charged. The wall may be regarded as a neutrally charged surface. Both positively and negatively charged objects are capable of being attracted to neutrally charged objects. The balloon was attracted to the wall surface, and thus, stuck to it. The two balloons moved away from one another because the similar charges they were carrying repelled each other. Like charges repel, unlike charges attract. In both cases, static electricity was at work.

Application—Tell students to look for metal stripping in the middle of the road in front of a toll booth. Ask students what purpose the metal strands have. (When vehicles travel on the highway, they build up static electricity. As vehicles rub on the strands of metal, the

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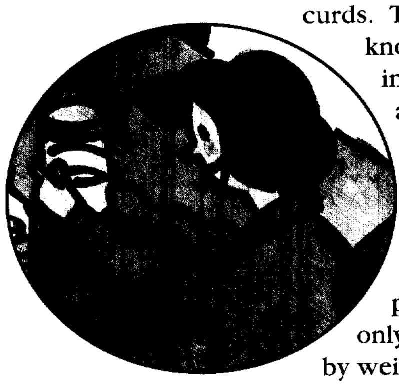
stored static electricity is discharged into the ground. If the strips were not present, a spark would pass between the driver and the toll booth operator.)

CHEMISTRY

Solid Milk—Understanding the nature of colloids.

Exploration—Working in small groups, ask the students to fill a baby food jar with fresh whole milk. Add two tablespoons of vinegar and stir gently. Allow the container to remain undisturbed for five minutes. The milk will separate into two parts—white solid lumps and a clear liquid. Ask the students to explain the results.

Concept Introduction—Milk is an excellent example of a colloid. Vinegar (acetic acid) causes the undissolved particles to join together by a process known as coagulation, forming solids of variable size called curds. The liquid portion, known as whey, is rich in lactose, minerals, and vitamins, and contains lactalbumin and traces of fat.



Milk contains a high percentage of protein, even though only about 3.5 percent by weight is protein. Much of the protein is in the form of casein molecules, which coagulate into small solids called micelles. The presence of calcium ions in milk converts the milk protein caseinogen into paracasein. Calcium ions react with paracasein to destabilize the molecular structure, resulting in coagulation.

Application—If the calcium is removed from milk, it will not coagulate. Calcium ions can be removed by adding sodium citrate. As an extension activity, students could design a simple experiment to test the role of calcium in milk coagulation under different temperatures.

STUDENT RESPONSES

Chinn and Brewer (1993), in their article on the role of anomalous data in knowledge acquisition, address a vital question in science education: "How do students respond when their current beliefs about the physical world conflict with the information presented during science instruction?" Chinn and Brewer believe that the "issue is critical for two reasons." The first reason relates to the fact that, "encountering contradictory information is a very common occurrence when one is learning science." The second reason dwells on the observation that "students typically resist giving up their pre-instructional beliefs. Instead of abandoning or modifying their pre-instructional beliefs in the face of new, conflicting data and ideas, students often staunchly maintain the old ideas and reject or distort the new ideas."

As science educators, we cannot afford to leave scientific discrepant events unexplained. Earlier, we pointed out Iran-Nejad's (1990) observation about students who take a "deep approach" to learning. Chinn and Brewer (1993) identify that, "Deep processing...can be enhanced...by fostering personal involvement in the issue and by ensuring that students know that they will have to justify their reasoning." To ensure the deep processing of science concepts and principles by students, we recommend the use of the learning cycle as an instructional strategy, especially since it promotes logical reasoning and applications of appropriate psychomotor skills. ✧

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